



Original Research

Parametric Estimation of Factors Associated with Prediction of Calving in Surti Buffaloes Using Ordinal Regression

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Abstract

Accurate prediction of calving is a key factor for profitable livestock farming. A depression on rump near sacrum due to relaxation of sacro-sciatic ligament is a characteristic sign of animal approaching calving. Present study was an effort to measure the depth of depression on rump region and vulvar zoometry in 44 pregnant Surti buffaloes. All the buffaloes were measured for zoometry on alternate days for last 2 months of gestation. The date of calving was considered as day 0. The observations taken before 45 days prior to calving were considered as normal observation found in non-pregnant buffaloes. The observations taken 45, 30, 15, 10, 5, 2 and 0 days prepartum were selected for analysis. The mean depth of vulva was 1.80, 2.06, 2.70, 3.04, 3.44, 3.66 and 4.11 cm before 45, 30, 15, 10, 5, 2 and 0 day, respectively. The angle lateral to sacral crest was found to be reduced when animal approaches calving due to increase in depth in depression on rump. It was about 170° before 45 days of calving and 155° before 10 days of calving. When it decreases to 150° we can say that the calving may occur within two days. The depression of rump between anterior sacral crest to pin bone (D_2) was 2, 2.11, 2.88, 3.18, 3.66, 3.89, 4.37 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. The depth D_2 when exceeds 3.5- 4 cm is suggestive of calving within 2-5 days. The ordinal regression analysis of all predictors with six pre-calving groups (threshold) revealed that depth of vulva and angle on rump were significantly associated in prediction of calving day with 0.75 pseudo R^2 .

Key words: Buffalo, Calving, Ordinal regression, Pregnant, Prediction, Sacro-sciatic ligament, Vulva, Zoometry

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Introduction

Calving is one of the important event for dairy farmers from economic point of view. The future of dairy farm i.e. calves are also born during calving, hence, calving is a key element in livestock farming. Close observation of cattle in the last gestation period is essential to detect the onset of calving and therefore, to





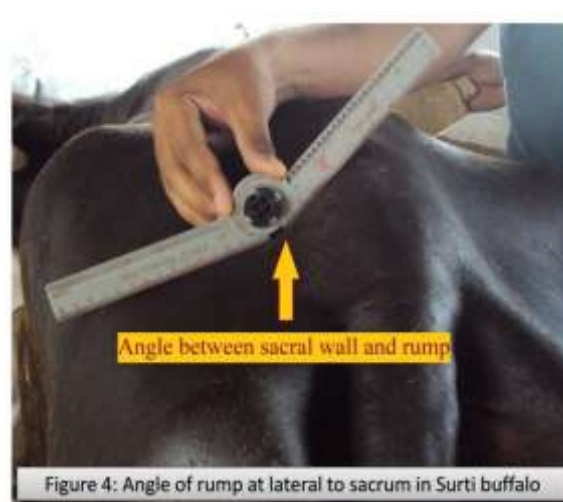
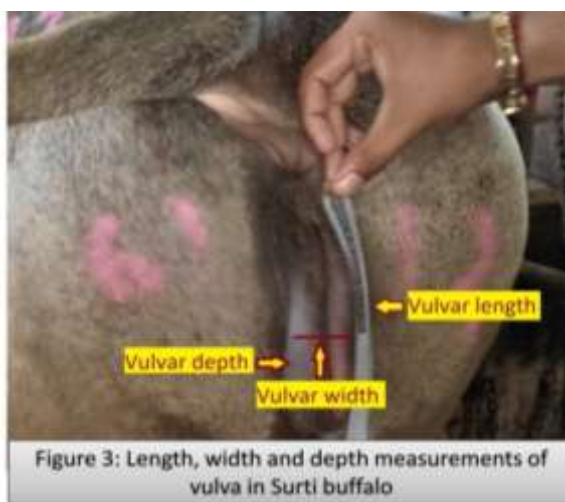
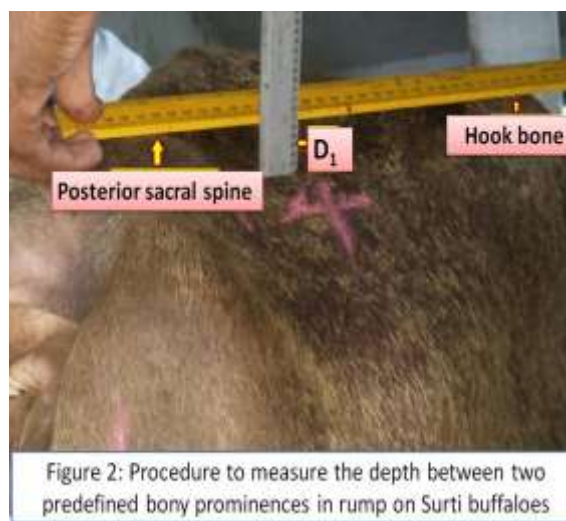
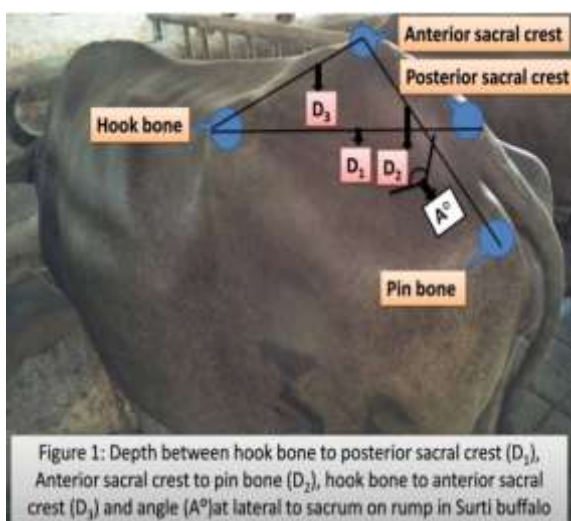
reduce neonatal losses (Jensen, 2012). It is recommended to place pregnant cows in maternity pens at least a day ago to calving. However, due to lack of accurate prediction of calving dates it is advised to put pregnant cows in maternity pens well in advance. Most of dairy farms in India are not having good numbers of maternity pens or not having accurate breeding record, therefore, many calving occurred in animal shed only. It leads to poor management of both dam and neonatal calf. Particularly calving that occurs at night in shed sometimes may results in death of calf. Sometimes in case of dystocia it may results in death of both dam and calf causing great economic loss to dairy farm owners. Dystocia and stillbirth have a significant impact on animal productivity because of expenses for veterinary treatment, calves not sold, reduced numbers of replacement heifers and lower milk production, which may lead to premature culling (Mottram, 1997; Bicalho *et al.*, 2008). Calving assistance, when appropriate, is associated with a significant decrease in calf mortality, placental retention and postpartum uterine infections, together with a shorter calving to conception interval (Paolucci *et al.*, 2010; Palombi *et al.*, 2013). Calving time prediction, allowing the provision of human assistance when necessary, is thus of critical importance for livestock profitability and animal welfare. Calving is characterized by hormonal, behavioural and physical changes (Titler *et al.*, 2015). Pelvic ligament relaxation (Berglund *et al.*, 1987), swelling of the vulva, mammary gland expansion and teat filling (Streyl *et al.*, 2011) might be used as visual signs to predict calving in the next 12 hours (Streyl *et al.*, 2011). Accurate prediction of calving time can be made by watching behavioural changes, vaginal temperature, hormonal assays or by intravaginal alarms (Palombi *et al.*, 2013) and data loggers attached to legs (Bachmann *et al.*, 2013; Titler *et al.*, 2015). Lying time decreases and lying bouts and activities increases as animal approaches calving (Jensen, 2012). However, the dairy farmers in India are traditionally predicting calving by watching depression occurred at rump due to relaxation of sacro-sciatic ligament during advance pregnancy and filling of udder and teat and enlargement of vulva. However, no much efforts have been carried out to quantify these changes associated with nearness of calving. Therefore, present study was carried out to test various measurements in respect to study their relations with prediction of calving.

Materials and Methods

There is prominent depression occurs during late gestation at lateral to sacrum on rump. This is due to relaxation of sacro-sciatic ligament associated with expectancy of calving. The said depression becomes deeper when cow or buffalo approaches to the calving. The experienced dairyman can roughly predict calving time by visual observation of rump. The said depression was tried to measure by possible ways in 44 pregnant Surti buffaloes at Livestock Research Station, Navsari. The depression was tried to measure by taking depth by three probable ways. Three bony prominences as fixed point at rump i.e. anterior and posterior sacral crest, hook bone and pin bone were considered. The depth at three points were measured in



either left or right rump by placing straight long foot roll on predefined two fixed points. The maximum depth occurred below foot roll starting from surface of rump was measured by another scale kept at right angle to first long foot roll (Fig. 2). Three probable measurements carried out were from hook bone to anterior sacral crest (D_3), hook bone to posterior sacral crest (D_2) and hook bone to pin bone (D_1) as depicted in Fig. 1. The vulvar depth, length and width were also measured by scale (Fig. 3). The angle occurred between lateral sacral wall and slope of rump was measured by goniometer (Fig. 4). All the selected buffaloes were observed daily in morning before two months of expected calving.



Swelling and enlargement of vulva was measured by taking its length, width and depth. The details of various zoometrical measurements taken is illustrated and explained in Fig. 1 to Fig. 4.

All the buffaloes were measured for said parameters daily until their calving. After calving the observations taken on calving day and before 2, 5, 10, 15, 30 and 45 days were selected for analysis. The observation taken on day of calving was considered as 0 day. Observation before 45 days of calving was considered as



normal measurement. The dependent variable i.e. days remaining to calving 0, 2, 5, 10, 15, 30 and 45 days was grouped as ordinal variables 1, 2, 3, 4, 5, 6 and 7, respectively for ordinal regression analysis. The data were subjected for analysis as per Snedecor and Cochran (1989) and means were analyzed by using one way ANOVA technique. The Duncan's method was used to compare various means. The ordinal regression analysis of data was made by using SPSS software in which days before calving was threshold whereas observations were considered as location. An ordered logit model was estimated to investigate whether 7 covariates (vulvar depth, length, width, D₁, D₂, D₃ and Angle) to predict days remained in calving ("day of calving", 2, 5, 10, 15, 30 and 45 days prior to calving) have any association or not.

Results and Discussion

The effect of day before calving on various zoometrical parameters under study is presented in Table 1. It shows that depth of vulva was 1.80, 2.06, 2.70, 3.04, 3.44, 3.66 and 4.11 cm before 45, 30, 15, 10, 5, 2 and 0 day, respectively. It is showing increasing trend from particularly from 30 day before calving to day of calving. Roughly it can be said that depth of vulva become double than normal before 5 days of calving. This predictor is also very easy to measure, hence, valuable. The length of vulva was 15.98, 16.66, 19.07, 19.22, 20.65, 21.32 and 22.55 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. It is also showing increasing trend, however, it is not much altered from 30 to 10 days before calving. The width of vulva was 6.07, 6.11, 7.20, 7.65, 8.37, 8.83 and 10.06 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. It was found much increased from day 15 to day of calving. The increase in size of vulva before calving was occurred simultaneously with days approaching to calving may be good predictors of expected calving (Streyl *et al.*, 2011).

Table 1: Effect of days before calving on zoometry (Cm) of vulva and rump in Surti buffaloes (n=44)

Parameter	Days Before Calving						DOC	P
	45	30	15	10	5	2	0	
Depth of vulva	1.80 ^a ± 0.09	2.06 ^a ± 0.09	2.70 ^b ± 0.07	3.04 ^c ± 0.09	3.44 ^d ± 0.09	3.66 ^d ± 0.10	4.18 ^e ± 0.12	0
Length of vulva	15.98 ^a ± 0.52	16.66 ^a ± 0.49	19.07 ^b ± 0.36	19.22 ^b ± 0.53	20.65 ^c ± 0.46	21.32 ^{cd} ± 0.42	22.55 ^d ± 0.43	0
Width of vulva	6.07 ^a ± 0.19	6.11 ^a ± 0.14	7.20 ^b ± 0.18	7.65 ^{bc} ± 0.19	8.37 ^{cd} ± 0.32	8.83 ^d ± 0.29	10.06 ^e ± 0.40	0
D ₁	1.48 ^a ± 0.10	1.69 ^a ± 0.09	2.47 ^b ± 0.15	2.77 ^b ± 0.18	3.20 ^c ± 0.15	3.38 ^c ± 0.14	4.03 ^d ± 0.15	0
D ₂	2.00 ^a ± 0.10	2.11 ^a ± 0.08	2.88 ^b ± 0.15	3.18 ^b ± 0.18	3.66 ^c ± 0.15	3.89 ^c ± 0.12	4.37 ^d ± 0.13	0
D ₃	1.47 ^a ± 0.11	1.76 ^{ab} ± 0.10	1.88 ^b ± 0.09	2.01 ^{bc} ± 0.09	2.30 ^{cd} ± 0.09	2.45 ^d ± 0.10	2.90 ^e ± 0.10	0
Angle at lateral to sacral wall	169.61 ^e ± 0.92	162.95 ^d ± 0.95	156.95 ^c ± 1.28	155.81 ^c ± 1.49	153.79 ^c ± 1.36	150.05 ^b ± 1.24	142.98 ^a ± 1.24	0

Means differing in superscript within rows are statistical different ($P < 0.05$)



Depth D_1 was 1.48, 1.69, 2.47, 2.77, 3.20, 3.38 and 4.03 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. Statistically it is significant (Table 1). It is showing increasing trend, particularly between 30 to 10 days before calving. It was roughly double on before 5 days than 30 days. It was 2.5 times more dipper at calving than normal depth. Shah *et al.* (2006) found that a gradual increase in the relaxation of the ligament was observed from day 100 of gestation (8 ± 1 mm) until day 2 prepartum (24 ± 2 mm). Thereafter, it showed a significant increase ($p < 0.05$) within 1 day before calving (31 ± 2 mm). Depth of rump beneath anterior sacral crest and pin bone (D_2) was 2, 2.11, 2.88, 3.18, 3.66, 3.89, 4.37 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. The hook bone and pin bone are very easy to locate, hence, it is very easy and accurate reading.

Further, the successive observations have more differences; therefore, it is having great value for prediction of calving. Based on mean value 3.5- 4 cm depression is suggestive of calving within 2-5 days. An increment of ≥ 5 mm from the preceding day measurement was the most useful and accurate in predicting calving within 24 h (Shah *et al.*, 2006). It is economical and easily applicable in the field condition. Depth D_3 was 1.47, 1.76, 1.88, 2.01, 2.30, 2.45 and 2.90 cm before 45, 30, 15, 10, 5, 2 and 0 days, respectively. It is also in increasing trend, however, the differences between subsequent observations are less, therefore, and it may not have much value as predictor of calving date. The depression is just lateral to sacral crest, so, it creates an angle between rump surface and sacral wall. This angle reduces when animal approaches calving due to increase in depth. It was about 170° before 45 days of calving and 155° before 10 days of calving. When it decreases to 150° we can say that the calving may occur within two days. An ordered logit model was estimated to investigate significance in studied seven covariates to predict days remained in calving ("day of calving", 2, 5, 10, 15, 30 and 45 days prior to calving) and summarized in Table 2.

Table 2: Ordinal regression estimates of explanatory variables to predict days remaining in calving

		Estimate (b)	Std. Error	Wald Statistics	df	Sig.
Threshold	[0-2 Day before calving = 1]	5.376	4.51	1.421	1	0.233
	[2-5 Day before calving = 2]	7.247	4.52	2.571	1	0.109
	[5-10 Day before calving = 3]	8.755	4.529	3.736	1	0.053
	[10-15 Day before calving = 4]	10.016	4.54	4.868	1	0.027
	[15-30 Day before calving = 5]	11.667	4.56	6.547	1	0.011
	[30- 45 Day before calving = 6]	13.733	4.593	8.94	1	0.003
Location	Vulvar depth	-1.777	0.269	43.623	1	0
	Length of vulva	-0.013	0.065	0.037	1	0.847
	Width of vulva	-0.195	0.119	2.704	1	0.1
	D_1	-0.067	0.272	0.061	1	0.805
	D_2	-0.47	0.245	3.672	1	0.055
	D_3	0.107	0.27	0.158	1	0.691
	Angle at lateral to sacral wall	0.11	0.022	23.927	1	0

Link function: Logit.





Together, the predictors accounted for a significant amount of variance in the outcome, likelihood ratio $\chi^2(3) = 271.74$, $p < .000$. Only vulvar depth, $b = -1.777$, $SE = 2.269$, Odd ratio = 0.17, $p = 0.00$ and Angle, $b = 0.110$, $SE = 0.022$, Odd ratio = 1.12, $p = 0.05$, were significantly associated with days remaining in calving. The pseudo R^2 values in ordinal regression model (e.g. Cox and Snell = 75.0% and Nagelkerke = 76.6%) indicates that our explanatory variable explains a relatively large proportion of the variation between days remaining in parturition. The goodness of fit statistics, $p = 1.00$, indicated that model fits the data well and it can be conclude that the data and the model predictions are similar.

The vulvar depth exhibited negative regression coefficients, indicating negative association with days remaining in parturition (Table 3). One standard deviation or 0.98 mm increase in vulvar depth decreases the odds of achieving a higher days remaining in parturition by a factor of 0.17. It means with every 0.98 mm increase in vulvar depth there is 83% shift of buffaloes into next lower group approaching calving.

Table 3: Odd ratio estimates of significant explanatory variables to predict days remaining in calving

Parameter	Regression Coefficient (b)	Mean	S.D (σ)	$y = \sigma * b$	$e^y = \text{Exp}(y)$
Vulvar Depth	-1.777	3	0.98	-1.75	0.17
Angle	0.11	155.75	11.18	1.23	3.42

However, angle exhibited positive regression coefficients, indicating positive association with days remaining in parturition. Each 11.18 degree decrease in the angle was associated with decreases the odds of achieving a higher days remaining in parturition by a factor of 3.42. For example, if angle decreases by 11.18 degree in one buffalo than 45 day group we can predict that particular buffalo may calve within 30 days (next lower group).

Conclusion

The onset of calving can be predicted by measuring of depth of vulva and angle at lateral sacral wall and rump in Surti buffaloes. The depth of vulva is about 3-3.5 cm before 2-5 days of calving. The angle was 155° before 10 days and it was 150° before two days of calving.

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